

THE
ORIGIN OF GNEISS

AND SOME

OTHER PRIMITIVE ROCKS.

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THE ORIGIN OF GNEISS AND SOME OTHER PRIMITIVE ROCKS. By Dr. ROBERT BELL, Assistant Director of the Geological Survey of Canada, Ottawa, Canada.

[ABSTRACT.]

GNEISS being probably the most abundant rock in the crust of the earth, it is rather singular that geologists have not yet come to a general agreement as to its usual process of formation. I say usual, for gneissoid rocks may be formed in more ways than one. For example, the granitic materials of some dykes are occasionally found to have assumed a gneissoid foliation parallel to the walls of the dykes, but no one would pretend that this was the normal mode of formation of the continuous gneiss of half a continent.

It is conceivable that a gneissoid, or rather a streaked, appearance may have been developed in certain granitic or syenitic rocks by a flowing movement, while in a plastic state, but such an appearance would, I think, be only very limited and would differ from ordinary gneissic bedding. The parallel mottling or clouding and isolated patches of a gneissoid character sometimes met with in granite or syenite may even be accounted for in other ways than from flow motion.

The bedding of gneiss differs from the streaking of slags by flowing, in being in continuous sheets which generally differ much in composition as well as color. It is difficult to imagine how flow-structure could communicate a distinctly and uniformly bedded arrangement throughout a depth of about ten miles of strata which is the ascertained thickness of one section of the Upper Laurentian alone. The presence of enormous beds of limestone, traceable continuously for a hundred miles or more, in the midst of these gneisses appears to me to be fatal to the flow-structure theory. Pressure will not account for the bedding of the Laurentian rocks, for no amount of pressure would separate a homogeneous mixture into distinct beds consisting of the different minerals. Or if pressure could separate these constituents, why have certain areas remained as granite or syenite?

The composition of different superimposed beds of gneiss often differs greatly, some being highly micaceous, while this mineral is scarce in others lying above or below. Again, considerable thicknesses may consist almost entirely of felspar, quartz or hornblende alone. I might mention in passing that hornblende is a very abundant constituent of our

gneisses — hornblende-gneiss being about as common as the so-called typical or mica-gneiss. Now a fused mixture of materials would not separate into layers of the different ingredients, and certainly not into such innumerable fine layers as make up the immense thicknesses of these gneisses. This is, I think, another fatal objection to the above theory. Then some of the bedded rocks of the Laurentian system bear such a close resemblance to or may rather be said to be identical with rocks which we can trace to a clastic and even sedimentary origin, that we are forced to conclude that they too have had a similar origin.

The Upper Laurentian rocks are differentiated into belts or groups of beds which can be traced over considerable distances on the ground and can thus be accurately mapped. After carefully working out a large area in this way Sir William Logan proved that the Upper Laurentian strata obey the ordinary structural laws governing stratified rocks when thrown into anticlinal and synclinal folds.

The lower Laurentian gneisses cannot be so easily separated into distinct belts, and limestones appear to be absent from this division, but many of them resemble the gneisses of the upper series so closely that it is altogether likely they had a similar origin. The Lower Laurentian strata are more contorted and at the same time more solid or massive than the Upper. They also occupy a much larger geographical area. In Canada the Upper Laurentian appears to be confined to a comparatively limited region extending from Georgian Bay eastward through the Ottawa valley and along the north side of the St. Lawrence. It also occurs in eastern Labrador and perhaps in Hudson's Strait.

In the country stretching from Lake Huron to Lake Temiscaming at the great bend of the Ottawa, and thence northward and in other directions, we have the best known and one of the largest areas of Huronian rocks in Canada. Having worked on these rocks for a number of years, I have had good opportunity for studying them and I beg to offer a few suggestions based on these observations, as to the origin of gneiss and some other primitive rocks.

In the region referred to we have vast quantities of a rock of which very little has hitherto been said by geologists. The late Mr. Alexander Murray mentioned certain varieties of it under the somewhat erroneous name of slate conglomerates. It is a grey or ash colored rock somewhat resembling sandstone, but usually massive or not separated into distinct parallel beds. It bruises readily under the hammer and may be easily broken or scratched, showing that it is largely composed of softer material than quartz. This rock as a matrix often contains large numbers of angular and rounded fragments of all degrees of coarseness from the size of pins' heads to that of pease, walnuts, a man's fist and even boulders. They consist for the most part of reddish quartz-felspar rock, granulite or binary granite, but fragments of other rocks occur in some varieties.

In the specimens which I have examined under the microscope the matrix is seen to consist principally of angular grains of felspar and rounded grains of quartz with a darker amorphous mineral filling the interspaces.

Much of this rock might be called a volcanic ash or breccia. The portions which are most free from pebbles or fragments are like the gold-bearing "whin rock" of the Nova Scotia miners. Some of it might be called sandstone, and much of it passes by insensible degrees into quartzite. It is, however, desirable to have a general name for this rock and I know of no single word which will better describe it than greywacké. Now this greywacké seems to me to be the raw material out of which some of the other Huronian rocks of this region have been formed. And from a study of the transformation of one rock into another I have come to the conclusion that the origins of several kinds of crystalline rocks have points in common and are mutually dependent on one another in a larger measure than we may have supposed. Thus if we can account for the origin of gneiss we shall have incidentally accounted for that of some other crystalline rocks at the same time.

Another rock which is very common in some parts of the area referred to is quartz-diorite. It presents considerable variety of conditions with the same constituents, passing from the purely crystalline kind through several stages less or more modified by water, as if it had flowed out under the sea and been variously affected by the water according to the volume of the rock-matter present; or in other cases it seems to have been entirely broken up and modified by the sea, the constituents without the addition of anything else resulting in an aqueous deposit. The quartz-diorite is another parent from which some of the other Huronian rocks are derived.

But to return to the greywacké, there are plenty of examples in this region which show that it passes directly into different varieties of quartz-syenite and gneiss and also that these rocks, as well as quartzites, clay-slates and dolomites may be derived from it.

In the direct formation of gneiss the materials of the more slaty varieties of the greywacké in some cases appear to separate somewhat into laminæ by a process of segregation. In other cases they gather themselves into grains or spots by a species of concretion. The complete conversion of these into finished gneisses is effected by a slightly further alteration through the agencies (whatever they may have been) which have produced the metamorphism of the crystalline rocks in general.

On the other hand the more massive varieties of the greywacké may be seen to change gradually into imperfect and then perfect or thoroughly crystalline quartz-syenite. The process seems to be largely due to concretionary action, both on a small and large scale.

The breaking up and modification of the materials of the greywacké by water appear to give rise to a great variety of quartzites on the one hand, and to clay-slates on the other. These materials may have been thrown into the sea either as mud or dust and become separated and deposited at once in different places as quartz-sand and clay, or the rock, after partial or complete consolidation, may have become broken up and reduced by the action of water so that the quartzose and the argillaceous portions could become separated and each deposited by itself, to form the quartzites and

clay-slates, which almost always accompany each other, as well as the greywackés of this region. The very fact of the association of these rocks suggests a connection of all these or a dependence of the quartzites and clay-slates upon the greywackés. The clay-slates frequently have layers of hornblende developed in them parallel to the bedding.

The quartzites are often largely mixed with the softer material of the greywacké, being in these cases merely the more silicious varieties of this rock which pass by insensible degrees into ordinary quartzite. The quartzite, however, is never entirely free from disseminated particles of felspar and this mineral in a crystalline form may be present in all proportions up to nearly half the whole mass.

These crystalline grains of felspar are generally light red in color and on very old surfaces they become dissolved out leaving little holes or pits. On slightly weathered surfaces they assume an opaque white, contrasting with the vitreous lustre of the quartzite, so that these surfaces have a speckled appearance. Where the felspar is uniformly and thickly scattered through massive quartzite, the rock is really a quartz-felspar or binary granite except that it has not yet become entirely crystalline but this change might readily be accomplished in time.

Where the felspar grains are disposed more thickly in rows in cross section, the rock looks very like gneiss even to the naked eye, and still more so under the microscope; and it might be converted into this rock by more complete alteration. On the west side of Lady Evelyn Lake between Temagami Lake and the Montreal River there is a mountain ridge 1,100 feet high, largely composed of this rock, standing nearly on edge, which a casual observer might easily take for gneiss although on closer examination it may be seen to be of elastic nature. The quartzite beds or quartzose gneisses of the Upper Laurentian in the county of Ottawa often contain felspar grains or crystals which weather out just like those of the Huronian quartzites and the outward appearance of the two rocks is so similar that hard specimens could not be distinguished from each other.

The curious varieties of modified quartz-diorite which have been mentioned are very abundant in some parts of the region under consideration—notably in the township of Denison. Extensive sections may be seen made up of beds of different thicknesses, but mostly thin, in each of which the quartz grains and the other components have been roughly separated from each other by the action of water. The bottom of each bed consists almost entirely of rounded grains of quartz; but, as we ascend, these become more and more mixed with argillaceous material till at the top there is pure clay-slate. The same arrangement is repeated in all the beds. In the vicinity of these beds there are others entirely of quartzite and of clay-slate, which I believe owe their origin to the disintegration of the quartz-diorite (probably when in a soft condition) and the separation and transportation of the original ingredients by water. If the thin alternating layers of quartz grains and slaty material were completely metamorphosed they would result in gneiss. The rocks of this region therefore appear to show three ways by which gneiss may be formed, namely,

by the direct conversion of the thin bedded or slaty varieties of greywacké, the alteration of the mixed quartz and felspar rock derived from other varieties of it and the alteration of the modified quartz diorites. I have also found a case where what appeared to have been a comminuted mass of felspar and decomposed hornblende which may have been derived from diorite was separating into interrupted layers of pure felspar with others of schist which by further alteration would form a rock like gneiss.

The clay slates associated with the greywackés are, in some parts of the region, black or nearly so. On the Onaping river these may be traced into a black breccia which is clearly of volcanic origin, largely developed near Onaping station on the Canadian Pacific Railway, which would show that the black color in Huronian slates is not necessarily organic and that any theory based on the supposition that it is so may be erroneous.

The dolomites of this region are evidently in most cases of a concretionary or segregated nature, and have probably been derived from the decomposition of the hornblende or the augite of the rocks with which they are associated. Small unstratified masses of this rock are not uncommon in the diorites, syenites and greywackés where they have been formed *in situ*, while the layers and stratified deposits may have been precipitated from waters which carried the carbonates of lime and magnesia to short distances from the hornblendic or augitic-bearing rocks undergoing decomposition.

During the process of converting the greywacké into syenite, the diffused iron which it contained has been gathered either into great numbers of strings or small veins of magnetite or into a few larger ones of the same ore which, however, I have never seen wide enough to be worked. Veins of this kind are interesting as showing the probability of the formation of more extensive larger ones of iron oxides without the existence of organic life as a means for the concentration of the metal.

The above notes touch on nearly all the stratified and some of the unstratified rocks of this Huronian region and it is hoped that they may have suggested some points of interest for discussion.